WO 9803031 98-09-30

>H04Q 7/38H

TY ORGANIZATION
eau

THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04Q 7/38, 7/22

A2

(11) International Publication Number: WO 98/03031

(43) International Publication Date: 22 January 1998 (22.01.98)

(21) International Application Number: PCT/SE97/01246

(22) International Filing Date: 8 July 1997 (08.07.97)

(30) Priority Data:
08/680,780 16 July 1996 (16.07.96) US

(71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventor: OLVERA-HERNANDEZ, Ulises; 329 Leslie Dowker, Sainte-Anne de Bellevue, Quebec H9X 3L2 (CA).

(74) Agent: TELEFONAKTIEBOLAGET LM ERICSSON; Patent and Trademark Dept., S-126 25 Stockholm (SE).

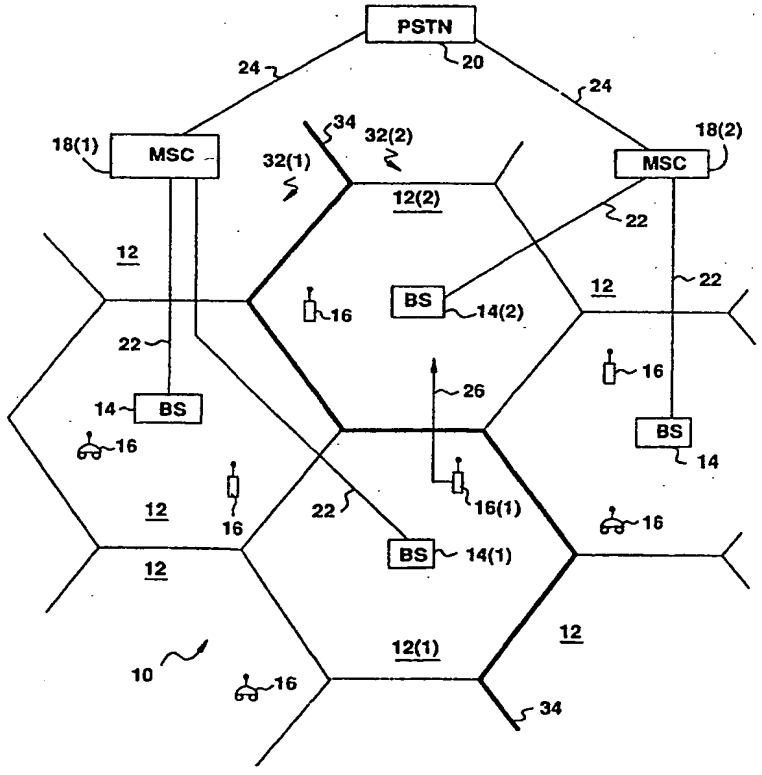
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD AND APPARATUS FOR INTER-SYSTEM HANDOFF WITHIN A PLURAL HYPERBAND SUPPORTING CELLULAR TELEPHONE NETWORK

(57) Abstract

A cellular telephone network (10) includes plural system areas (32) each having a plurality of cells (12). The system areas do not support cellular communications in all of the same hyperbands. When a verification signal strength measurement (118, 218) is needed, a message (114, 116) is sent from a first one of the system areas to a second one of the system areas, with the message including not only an identification for measurement of the traffic channel currently being used by a mobile station, but also an identification of the hyperband within which that traffic channel exists. The report (120, 122) on the results of the requested measurement and hyperband capabilities of target cell is then sent from the second system area to the first system area. From this information, the first system area may confirm (124, 224) that the measurement was made or was attempted in the proper hyperband and thus determine whether the second system would be able to support mobile station operation with respect to hyperband in the event of an inter-system hand off.



METHOD AND APPARATUS FOR INTER-SYSTEM HANDOFF WITHIN A PLURAL HYPERBAND SUPPORTING CELLULAR TELEPHONE NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

The present invention relates to cellular telephone networks and, in particular, to inter-system handoff of mobile stations in connection with a plural hyperband supporting cellular telephone network.

Description of Related Art

North American cellular communications have historically been implemented solely in the 800 MHZ Cellular hyperband. The Cellular hyperband is assigned two frequency bands (commonly referred to as the A frequency band and the B frequency band) for carrying and controlling communications. The most recent evolution in cellular communications services involves the adoption of three additional hyperbands for use in handling mobile and personal communications. Of these additional hyperbands, only the Personal Communication Services (PCS) hyperband in the 1900 MHZ frequency range has been completely defined. The PCS hyperband is specified to include six different frequency bands (A, B, C, D, E and F).

Each one of frequency bands specified for the Cellular and PCS hyperbands is allocated a plurality of voice or speech (traffic) channels, as well as access or control channel(s). The control channels are used to control or supervise the operation of mobile stations by means of information transmitted to and received from the mobile stations. Such information may include incoming call signals, outgoing call signals, page signals, page response signals, location registration signals, voice channel assignments, maintenance instructions, and cell selection or reselection instructions as a mobile station travels out of the radio coverage of one cell and into the radio coverage of another cell. The traffic channels are used to carry subscriber telephonic communications as well as messages requesting mobile station assistance in making hand-off evaluations and controlling the hand-off operation. The control and traffic channels may operate in either an analog mode, a digital mode, or a combination mode.

As the cellular telephone network has been upgraded to accommodate the newly made available hyperbands, instances have arisen where one cellular system area does not support the same hyperbands as its adjacent cellular system area. Thus, for example, a first cellular system area may support cellular operations in both the Cellular and PCS hyperbands, while an adjacent, second cellular system area inconsistently supports cellular operations only in the Cellular hyperband. This presents a communications problem when mobile stations roam between the two service areas, as it may become necessary for a mobile station to switch between the hyperbands as well as switch traffic channels at the point of hand-off. Furthermore, of perhaps even more concern with respect to communications is that the included verification process, wherein signal strength measurements are made from the target cell on the traffic channel currently being used by the mobile station, may be improperly performed or the results may be erroneous if the service area does not support the hyperband within which the mobile station is currently operating. Accordingly, there is a need then for a system and method for supporting inter-system hand-off, and in particular the included verification process, wherein the system and method accounts for differences and inconsistencies between system supported hyperbands.

SUMMARY OF THE INVENTION

In a cellular telephone network including plural system areas having inconsistent hyperband support, a message sent from a first one of the system areas to a second one of the system areas requesting the making of a verification signal strength measurement includes not only an identification of the traffic channel currently being used by a mobile station, but also an identification of the hyperband within which that traffic channel exists. Responsive thereto, a measurement is made, if possible, from the second system area in the identified hyperband on the traffic channel currently being used by the mobile station. A report on the results of the requested verification measurement is then sent from the second system area to the first system area for further processing. This report preferably includes an indication of the hyperband within which the verification measurement, if any, was made. From the report, the first system area can confirm the hyperband capabilities of the second system area, and thus

determine whether the second system area would support mobile station operation in the event of an inter-system hand-off.

In connection with the hand-off of the mobile station from the first system area to the second system area, the first system area requests from the second system area the assignment of a traffic channel. Responsive to that request, the second system area selects a traffic channel within a supported hyperband and reports on the selected channel, as well as the hyperband within which that selected traffic channel exists, to the first system area. From that report, the first system area can confirm the hyperband capabilities of the second system area, and thus determine whether the second system area would support mobile station operation in the event of an inter-system hand-off.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the method and apparatus of the present invention may be acquired by reference to the following Detailed Description when taken in conjunction with the accompanying Drawings wherein:

FIGURE 1 is a cell diagram illustrating an exemplary cell configuration for a plural hyperband supporting cellular telephone network in which the present invention may be implemented;

FIGURES 2A-2B are signal flow and network operation diagrams illustrating operation of the network of FIGURE 1 in connection with a verification-type hand-off of a mobile station from a cell within a first system area to a cell within a second system area; and

FIGURES 3A-3B are signal flow and network operation diagrams illustrating operation of the network of FIGURE 1 in connection with a blind-type hand-off of a mobile station from a cell within a first system area to a cell within a second system area.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIGURE 1 wherein there is shown a cell diagram illustrating an exemplary cell configuration for a plural hyperband supporting cellular telephone network 10 in which the present invention may be implemented. The cellular

telephone network 10 operates in accordance with one of a number of known air interface types including, for example, a digital time division multiple access (TDMA) protocol. In a digital TDMA cellular telephone network, for example, each cell 12 operates with an assigned set of transmission frequencies selected from one or more of the available hyperbands. The set of frequencies assigned to each cell 12 includes frequencies supporting both at least one control channel and a plurality of traffic channels, with the control and traffic channels operable in either or both an analog and/or a digital mode. Sets of assigned frequencies are different for adjacent cells 12, and such sets are not repeated for use by other cells except for those cells that are far enough away from each other to minimize the likelihood of adjacent or co-channel interference.

In the network 10, a base station 14 is provided for each of the cells 12. The base stations 14 engage in simultaneous communications with plural mobile stations 16 operating roughly within the area of the associated cell 12. The control channel assigned to each cell 12 is used to carry system control signals between the base station 14 and proximately located mobile stations 16, and also to assist in the network with mobile station cell reselection. Such control signals include call originations, page signals, page response signals, location registration signals, traffic channel assignments, maintenance instructions, and cell selection or re-selection instructions. The traffic channels provided in each cell 12 are used to carry subscriber voice or data communications between the base station 14 and proximately located mobile stations 16 and also to assist in the hand-off operation.

The base stations 14 are illustrated as being positioned at or near the center of each of the cells 12. However, depending on geography and other known factors, the base stations 14 may instead be located at or near the periphery of, or otherwise away from the centers of, each of the cells 12. In such instances, the base stations 14 may broadcast and communicate with mobile stations 16 located within the cells 12 using directional rather than omni-directional antennas. Each one of the base stations 14 includes a transmitter, a receiver, and a base station controller (none shown) connected to an antenna (also not shown) in a manner and with a configuration well known in the art.

The base stations 14 further communicate via signaling links and voice trunks 22 with a central control station, commonly referred to as a mobile switching center 18, which functions to control operation of the network 10. The mobile switching centers 18 are interconnected with each other and to the public switched telephone network (PSTN) 20 by signaling links and voice trunks 24. The mobile switching centers 18 operate to selectively connect subscriber voice and data communications to the mobile stations 16 through its base stations 14. Thus, the mobile switching center 18 controls system operation through and in response to the transmission of control signals over the control channels to set-up on the traffic channels calls that are either originated by or terminated at the mobile stations 16. The mobile switching center 18 further controls, through and in response to control and traffic channel transmissions, the handoff of a subscriber communication from a traffic channel of one cell 12 to a traffic channel of another cell as the subscriber mobile station 16 roams throughout the cellular service area during an ongoing communication.

It is common within one overall cellular service area to have a plurality of system areas 32 (differentiated from each other by the fact that they have different system identifications (SIDs) and perhaps have different service providers). A boundary 34, passing between cells 12 along the border between two system areas 32, is shown in bold in FIGURE 1 to delimit the physical extent of each of the illustrated system areas. In this illustrated example, it will be noted that the cells 12 within two system areas 32 are served by different mobile switching centers 18.

North American cellular communications have historically been implemented solely in the 800 MHZ Cellular hyperband. The most recent evolution in cellular communications services involves the adoption of three additional hyperbands for use in handling mobile and personal communications. Of these additional hyperbands, only the Personal Communication Services (PCS) hyperband in the 1900 MHZ frequency range has been completely defined. In the network 10 illustrated in FIGURE 1, mobile switching center 18(1) for system area 32(1) supports mobile station 16 operation in both the Cellular hyperband and the PCS hyperband. The mobile switching center 18(2) for system area 32(2), however, supports mobile station 16 operation only in the

Cellular hyperband. Thus, there exists in the network 10 inconsistent hyperband support between the plurality of system areas 32.

There are a number of mobile stations 16 shown operating within the service area of the network 10. These mobile stations 16 may comprise Cellular hyperband only capable mobile stations, PCS hyperband only capable mobile stations, or dual frequency (Cellular and PCS hyperband) capable mobile stations. With respect to the Cellular hyperband only capable mobile stations, they may operate in an analog mode only or in a dual (analog and digital) mode. With respect to the PCS hyperband only capable mobile stations, they operate in a digital mode only. Finally, with respect to the dual frequency (Cellular and PCS hyperband) capable mobile stations, they may operate in a digital mode only or in a dual (analog and digital) mode. It will, of course, be understood that Cellular hyperband only capable mobile stations may operate within the cells 12 of both system areas 32(1) and 32(2) of FIGURE 1 using any of the traffic or control channel frequencies of the Cellular hyperband. PCS hyperband only capable mobile stations, however, may operate within the cells 12 of system area 32(1) using any of the traffic or control channel frequencies of PCS hyperband. Dual frequency (Cellular and PCS hyperband) capable mobile stations may operate within the cells 12 of both system areas 32(1) and 32(2), and use traffic or control channel frequencies of both the Cellular and PCS hyperbands while in system area 32(1), but may only use traffic or control channel frequencies of the Cellular hyperband while within system area 32(2).

As the mobile stations 16 move within the service area of the network 10, there will be instances where a mobile station will pass between two cells 12 within a single system area 32, or from one cell in a first system area 32(1) to another cell in a second system area 32(2). In moving between the cells 12, the mobile stations 16, in conjunction with base station 14 information and orders exchanged with and between the mobile switching centers 18, have an opportunity through hand-off to change the base station through which cellular radio communications are being effectuated. For example, mobile station 16(1) is shown moving in the direction of arrow 26 from system area 32(1) into system area 32(2). Because the network 10 supports plural hyperbands and includes single and multiple hyperband supporting system areas 32, by

moving between cells and changing base stations as a result thereof, the mobile stations 16 may not only change the traffic or control channel frequency used for communication, but may further change the hyperband over which communications are being effectuated. It is important in such instances of inter-system hand-off that the mobile switching centers 18 be informed not only of the hyperband within which communications are being effected in the currently serving cell, but also of the hyperband capabilities for communication within the target cell.

Reference is now made in combination to FIGURES 1 and 2A-2B wherein FIGURES 2A-2B are signal flow and network operation diagram illustrating operation of the network 10 of FIGURE 1 in connection with a verification-type hand-off of a mobile station 16(1) from a cell 12(1) within a first system area 32(1) to a cell 12(2) within a second system area 32(2). In this instance, the mobile switching center 18(1) for system area 32(1) supports mobile station 16 operation in both the Cellular hyperband and the PCS hyperband, while the mobile switching center 18(2) for system area 32(2) supports mobile station 16 operation in the Cellular hyperband only. The mobile station 16(1), operating if capable in accordance with known mobile assisted hand-off (MAHO) principles, periodically makes downlink signal strength measurements 100 on the traffic channel (of cell 12(1)) that is currently being used, and also periodically makes downlink signal strength measurements 102 on the control channels of network identified cells 12, including cell 12(2), which neighbor the cell 12(1). These signal strength measurements are reported 104 to the base station 14(1) for the currently serving cell 12(1). The base station 14(1) concurrently makes uplink signal strength measurements 106 on the traffic channel that is currently being used by the mobile station 16(1).

The base station 14(1) processes the mobile station 16(1) reported 104 downlink signal strength measurements (100 and 102), if available, and the base station made uplink signal strength measurements (106) to determine first whether a hand-off is necessary (action 108) and second, if yes, to which cell or cells the hand-off could and/or should preferably occur (action 110). In this example, it is assumed that the base station 14(1) determines 108 from deteriorating measured uplink and/or downlink signal strengths that a hand-off is necessary. It is further assumed that an identification

110 is made of cell 12(2) in system area 32(2) as the preferred target cell for hand-off. A request 112 for hand-off including information comprising an identification of the currently serving cell 12(1), the traffic channel being used for communication with mobile station 16(1) in cell 12(1), the hyperband within which that traffic channel exists, the time slot (for a digital traffic channel) carrying the cellular communication, and the target cell 12(2) for hand-off, is then sent by the base station 14(1) to the serving mobile switching center 18(1). A hand-off if approved in this instance would comprise an inter-system hand-off because the target cell 12(2) is served by a mobile switching center 18(2) (serving system area 32(2)) different from the mobile switching center 18(1) serving the current cell 12(1) (serving system area 32(1)). The foregoing description is only an example of the procedure used in making the determination to institute a hand-off.

The currently serving mobile switching center 18(1) then signals 114 the mobile switching center 18(2) associated with the target cell 12(2) requesting verification of base station 14(2) communications capability with the mobile station 16(1). The signal 114, like the request 112 sent by the base station 14(1), includes information comprising an identification of the currently serving cell 12(1), the traffic channel being used for communication with mobile station 16(1) in cell 12(1), the hyperband within which that traffic channel exists, the time slot (for a digital traffic channel) carrying the cellular communication, the target cell 12(2) for hand-off, and the hyperband capabilities of the mobile station. Responsive thereto, the mobile switching center 18(2) signals 116 the base station 14(2) for the target cell 12(2) to make a verifying signal strength measurement (action 118) on the traffic channel currently being used by the mobile station 16(1) in the currently serving cell 12(1). This measurement should take into account the hyperband within which that traffic channel exists, and perhaps, if necessary, the time slot (for a digital traffic channel) carrying the cellular communication.

The base station 14(2) then reports 120 the results of the verification signal strength measurement to the mobile switching center 18(2), which then forwards 122 the results back to the mobile switching center 18(1). This report 120 not only identifies whether the verification signal strength measurement was successful, but also

identifies the particular hyperband within which the verification measurement, if any, was made, along with an identification of the hyperband capabilities of the cell. The results are then processed (action 124) by the mobile switching center 18(1) to determine whether a hand-off to target cell 12(2) should be made. This determination takes into account not only the success and strength of the verification measurement, but also the hyperband capabilities of both the mobile station 16(1) and the target cell 12(2). If the determination is affirmative, the mobile switching center 18(1) signals 126 the mobile switching center 18(2) requesting assignment (and reservation) of a traffic channel (and time slot therein for a digital traffic channel) for hand-off to the target cell 12(2). Both the base station 14(2) and mobile switching center 18(1) are then informed 128 of the assignment by the mobile switching center 18(2) of the traffic channel (and hyperband within which that traffic channel exists) in the target cell 12(2). The mobile switching center 18(1) then confirms (action 130) the propriety of the assigned traffic channel and hyperband in view of mobile station 16(1) communications capabilities, and signals 132 the mobile station 16(1) via the base station 14(1) for the currently serving cell 12(1) with a handover command directing the mobile station to switch to the assigned traffic channel (and time slot therein if appropriate) in the target cell 12(2). The mobile station 16(1) then tunes to and accesses 134 the assigned traffic channel (in the proper time slot). When the base station 14(2) detects the mobile station access (action 136), the mobile switching centers 18(1) and 18(2) are informed 138, and the call is switched 140 to the mobile switching center 18(2) for further handling to complete the hand-off procedure.

The operation of the network 10 in connection with the verification-type hand-off procedure illustrated in FIGURE 2 may be better understood by reference to the following examples.

In a first example, the mobile station 16(1) comprises a PCS hyperband only capable mobile station which operates only in digital mode, and is currently utilizing digital traffic channel number 1 of cell 12(1) in the PCS hyperband. As the mobile station 16(1) moves, the base station 14(1) processes available signal strength measurements (100, 102 and/or 106) and determines that a hand-off is necessary 108. The base station 14(1) further determines that cell 12(1), among perhaps other

neighboring cells 12, comprises a candidate target cell for that hand-off. The base station 14(1) then requests 112 a hand-off from the mobile switching center 18(1). This request includes an identification of not only traffic channel number 1, but also that traffic channel number 1 is within the PCS hyperband. This is important because the Cellular hyperband may also include a traffic channel number 1, and absent an identification of the hyperband, the traffic channel number identification provided may be ambiguous with respect to a system area 32 supporting plural hyperbands.

The mobile switching center 18(1) then requests (with signals 114 and 116) that base station 14(2) for the target cell 12(2) perform a verifying signal strength measurement (action 118) within the PCS hyperband on the traffic channel number 1 currently being used by the mobile station 16(1). Because the service area 32(2) supports cellular operations in the Cellular hyperband only, the base station 14(2) cannot make the requested verification signal strength measurement in the PCS hyperband. Accordingly, the base station 14(2) may report 120 and 122 that it cannot make the requested verification signal strength measurement. Alternatively, the base station 14(2) may mistakenly make the verification signal strength measurement on traffic channel number 1 of the Cellular hyperband, and the report 120 and 122 will include an indication that the measurement was made (albeit improperly) in the Cellular hyperband. In either case, the processing 124 of the report confirms the Cellular only hyperband capabilities of target cell 12(2), and determines that a hand-off to target cell 12(2) is not possible with respect to PCS hyperband mobile station 16(1). That cell is then discarded as a viable target cell for hand-off. Accordingly, for PCS hyperband only capable mobile station 16(1), no attempt is made to hand-off to a cell in a service area 32(2) that supports only Cellular hyperband operations.

In a second example, the mobile station 16(1) comprises a Cellular hyperband only capable mobile station which operates in either an analog only mode or a dual analog/digital mode, and is currently utilizing traffic channel number 2 in the Cellular hyperband. As the mobile station 16(1) moves, the base station 14(1) processes available signal strength measurements (100, 102 and/or 106) and determines that a hand-off is necessary 108. The base station 14(1) further determines that cell 12(1), among perhaps other neighboring cells 12, comprises a candidate target cell for that

hand-off. The base station 14(1) then requests 112 a hand-off from the mobile switching center 18(1). This request includes an identification of not only traffic channel number 2, but also that traffic channel number 2 is within the Cellular hyperband. This is important because the PCS hyperband may also include a traffic channel number 2, and absent an identification of the hyperband, the traffic channel identification provided may be ambiguous with respect to a system area 32 supporting plural hyperbands.

The mobile switching center 18(1) then requests (with signals 114 and 116) that base station 14(2) for the target cell 12(2) perform a verifying signal strength measurement (action 118) within the Cellular hyperband on the traffic channel number 2 currently being used by the mobile station 16(1). Because the service area 32(2) supports cellular operations in the Cellular hyperband only, the base station 14(2) should be capable of making the requested verification signal strength measurement in the Cellular hyperband. The measurement may then be made but be unsuccessful, indicating insufficient signal strength for mobile station 16(1) communication with base station 14(2). The measurement may also fail to be made, perhaps because the base station 14(2) is not functioning properly. Alternatively, the measurement may be made and be successful, indicating sufficient signal strength for mobile station 16(1) communication with base station 14(2). In any of the foregoing cases, the report 120 and 122 from the base station 14(2) includes an indication confirming that a Cellular hyperband measurement was to be made.

If the measurement is made and is successful, or if the measurement fails to be made, the processing 124 confirms the Cellular only hyperband capabilities of target cell 12(2), and may then result in the selection and approval of the target cell 12(2) for hand-off. The mobile switching center 18(2) is then signaled 126 to request assignment (and reservation) of a traffic channel for hand-off to the target cell 12(2). In order to maximize the chances of a successful hand-off, the assigned traffic channel typically comprises an analog traffic channel within the Cellular hyperband. Following confirmation 130 of the selected channel, a handover command 132 is broadcast to the mobile station 16(1) via the base station 14(1). The assigned traffic channel is then accessed 134 by the mobile station 16(1), and the call is switched 140 to the mobile

switching center 18(2) for further handling to complete the hand-off procedure. Alternatively, if the measurement is made but is unsuccessful (indicating insufficient signal strength), the processing 124 again confirms the Cellular only hyperband capabilities of target cell 12(2), and determines that a hand-off is not possible. That cell 12(2) is then discarded as a viable target cell for hand-off, and no attempt is made to hand-off to that cell.

In a third example, the mobile station 16(1) comprises a dual frequency (Cellular and PCS hyperband) capable mobile station which operates in either a digital only mode or a dual analog/digital mode, and is currently utilizing traffic channel number 3 in the Cellular hyperband. As the mobile station 16(1) moves, the base station 14(1) processes available signal strength measurements (100, 102 and/or 106) and determines that a hand-off is necessary 108. The base station 14(1) further determines that cell 12(1), among perhaps other neighboring cells 12, comprises a candidate target cell for that hand-off. The base station 14(1) then requests 112 a hand-off from the mobile switching center 18(1). This request includes an identification of not only traffic channel number 3, but also that traffic channel number 3 is within the Cellular hyperband. This is important because the PCS hyperband may also include a traffic channel number 3, and absent an identification of the hyperband, the traffic channel identification provided may be ambiguous with respect to a system area 32 supporting plural hyperbands.

The mobile switching center 18(1) then requests (with signals 114 and 116) that base station 14(2) for the target cell 12(2) perform a verifying signal strength measurement (action 118) within the Cellular hyperband on the traffic channel number 3 currently being used by the mobile station 16(1). Because the service area 32(2) supports cellular operations in the Cellular hyperband only, the base station 14(2) should be capable of making the requested verification signal strength measurement in the Cellular hyperband. The measurement may then be made but be unsuccessful, indicating insufficient signal strength for mobile station 16(1) communication with base station 14(2). The measurement may also fail to be made, perhaps because the base station 14(2) is not functioning properly. Alternatively, the measurement may be made and be successful, indicating sufficient signal strength for mobile station 16(1)

communication with base station 14(2). In any of the foregoing cases, the report 120 and 122 from the base station 14(2) includes an indication confirming that a Cellular hyperband measurement was to be made.

If the measurement is made and is successful, or if the measurement fails to be made, the processing 124 confirms the Cellular only hyperband capabilities of target cell 12(2) and may then result in the selection and approval of the target cell 12(2) for hand-off. The mobile switching center 18(2) is then signaled 126 to request assignment (and reservation) of a traffic channel for hand-off to the target cell 12(2). In order to maximize the chances of a successful hand-off, the assigned traffic channel typically comprises an analog traffic channel in the Cellular hyperband. No change in the hyperband being used by the mobile station 16(1) is necessary. Following confirmation 130 of the selected channel, a handover command 132 is then broadcast to the mobile station 16(1) via the base station 14(1). The assigned traffic channel is then accessed 134 by the mobile station 16(1), and the call is switched 140 to the mobile switching center 18(2) for further handling to complete the hand-off procedure. Alternatively, if the measurement is made but is unsuccessful (indicating insufficient signal strength), the processing 124 again confirms the Cellular only hyperband capabilities of target cell 12(2), and determines that a hand-off is not possible. That cell 12(2) is then discarded as a viable target cell for hand-off, and no attempt is made to hand-off to that cell.

In a fourth example, the mobile station 16(1) comprises a dual frequency (Cellular and PCS hyperband) capable mobile station which operates in either an analog only mode or a dual analog/digital mode, and is currently utilizing traffic channel number 4 in the PCS hyperband. As the mobile station 16(1) moves, the base station 14(1) processes available signal strength measurements (100, 102 and/or 106) and determines that a hand-off is necessary 108. The base station 14(1) further determines that cell 12(1), among perhaps other neighboring cells 12, comprises a candidate target cell for that hand-off. The base station 14(1) then requests 112 a hand-off from the mobile switching center 18(1). This request includes an identification of not only traffic channel number 4, but also that traffic channel number 4 is within the PCS hyperband. This is important because the Cellular hyperband may also include a traffic channel

number 4, and absent an identification of the hyperband, the traffic channel identification provided may be ambiguous.

The mobile switching center 18(1) then requests (with signals 114 and 116) that base station 14(2) for the target cell 12(2) perform a verifying signal strength measurement (action 118) within the PCS hyperband on the traffic channel number 4 currently being used by the mobile station 16(1). Because the service area 32(2) supports cellular operations in the Cellular hyperband only, the base station 14(2) cannot make the requested verification signal strength measurement in the PCS hyperband. Accordingly, the base station 14(2) may report 120 and 122 that it cannot make the requested verification signal strength measurement. Alternatively, the base station 14(2) may mistakenly make the verification signal strength measurement on traffic channel number 4 of the Cellular hyperband, and the report 120 and 122 will include an indication that the measurement was made (albeit improperly) in the Cellular hyperband. In either case, the processing 124 of the report confirms the Cellular only hyperband capabilities of target cell 12(2), and accordingly may result in a discarding of cell 12(2) as a viable target cell for hand-off.

Alternatively, the cell 12(2) may be retained as the best available option for hand-off in spite of the inability to make a verification signal strength measurement on traffic channel number 4 of the PCS hyperband. This is because the mobile station 16(1) is dual frequency (Cellular and PCS hyperband) capable. Through processing 124, the target cell 12(2) is then selected and approved for hand-off. The signal 126 is then sent to mobile switching center 18(2) to request assignment (and reservation) of a traffic channel for hand-off to the target cell 12(2). In order to maximize the chances of a successful hand-off, the assigned traffic channel typically comprises an analog traffic channel in the Cellular hyperband. Following confirmation 130 of the selected channel, a handover command 132 is broadcast to the mobile station 16(1) via the base station 14(1). A hyperband change from PCS to Cellular is effectuated, and the assigned traffic channel is accessed 134 by the mobile station 16(1). The call is then switched 140 to the mobile switching center 18(2) for further handling to complete the hand-off procedure.

Reference is now made in combination to FIGURES 1 and 3A-3B wherein FIGURES 3A-3B and signal flow and network operation diagrams illustrating operation of the network of FIGURE 1 in connection with a blind-type hand-off of a mobile station 16(1) from a cell 12(1) within a first system area 32(1) to a cell 12(2) within a second system area 32(2). The blind-type hand-off differs from the verification-type hand-off of FIGURES 2A-2B, as will be seen, primarily with respect to the point in time at which the verification signal strength measurement is made.

The mobile switching center 18(1) for system area 32(1) supports mobile station 16 operation in both the Cellular hyperband and the PCS hyperband, while the mobile switching center 18(2) for system area 32(2) supports mobile station 16 operation in the Cellular hyperband only. The mobile station 16(1), operating in accordance with known mobile assisted hand-off (MAHO) principles, periodically makes downlink signal strength measurements 200 on the traffic channel (of cell 12(1)) that is currently being used, and also periodically makes downlink signal strength measurements 202 on the control channels of network identified cells 12, including cell 12(2), which neighbor the cell 12(1). These signal strength measurements are reported 204 to the base station 14(1) for the currently serving cell 12(1). The base station 14(1) concurrently makes uplink signal strength measurements 206 on the traffic channel that is currently being used by the mobile station 16(1).

The base station 14(1) processes the mobile station 16(1) reported 204 downlink signal strength measurements (200 and 202), if available, and the base station made uplink signal strength measurements (206) to determine first whether a hand-off is necessary (action 208), and second, if yes, to which cell or cells the hand-off should preferably occur (action 210). In this example, it is assumed that the base station 14(1) determines 208 from deteriorating measured uplink and downlink signal strengths that a hand-off is necessary. It is further assumed that an identification 210 is made of cell 12(2) in system area 32(2) as the target cell for hand-off. A request 212 for hand-off including information comprising an identification of the currently serving cell 12(1), the traffic channel being used for communication with mobile station 16(1) in cell 12(1), the hyperband within which that traffic channel exists, the time slot (for a digital traffic channel) carrying the cellular communication, and the target cell 12(2) for hand-

off, is then sent by the base station 14(1) to the serving mobile switching center 18(1). A hand-off if approved in this instance would comprise an inter-system hand-off because the target cell 12(2) is served by a mobile switching center 18(2) (serving system area 32(2)) different from the mobile switching center 18(1) serving the current cell 12(1) (serving system area 32(1)). The foregoing description is only an example of the procedure used in making the determination to institute a hand-off.

The currently serving mobile switching center 18(1) then signals 214 the mobile switching center 18(2) associated with the target cell 12(2) requesting assignment (and reservation) of a traffic channel (and time slot therein for a digital traffic channel) for hand-off to the target cell 12(2). The signal 214, like the request 212 sent by the base station 14(1), includes information comprising an identification of the currently serving cell 12(1), the traffic channel being used for communication with mobile station 16(1) in cell 12(1), the hyperband within which that traffic channel exists, the time slot (for a digital traffic channel) carrying the cellular communication, the target cell 12(2) for hand-off, and the hyperband capabilities of the mobile station. Responsive thereto, the mobile switching center 18(2) signals 216 the base station 14(2) for the target cell 12(2) to make a verifying signal strength measurement (action 218) on the traffic channel currently being used by the mobile station 16(1) in the currently serving cell 12(1). This measurement should take into account the hyperband within which that traffic channel exists, and perhaps, if necessary, the time slot (for a digital traffic channel) carrying the cellular communication. The base station 14(2) then reports 220 the results of the verification signal strength measurement to the mobile switching center 18(2). If the verification was successful, both the base station 14(2) and mobile switching center 18(1) are then informed 222 of the assignment by the mobile switching center 18(2) of the traffic channel (and hyperband within which that traffic channel exists) in the target cell 12(2). This differs from the process of FIGURES 2A-2B where verification was performed prior to requesting assignment of the traffic channel.

The mobile switching center 18(2) then forwards 226 the results of the verification and assignment back to the mobile switching center 18(1). This report 226 not only identifies whether the verification signal strength measurement was successful, but also identifies the particular hyperband within which the measurement, if any, was

made, along with an identification of the hyperband capabilities of the cell. The results are then processed (action 228) by the mobile switching center 18(1) to determine whether a hand-off to target cell 12(2) should be made. This determination takes into account not only the success and strength of the verification measurement, but also the hyperband capabilities of both the mobile station 16(1) and the target cell 12(2). If the determination is affirmative, the mobile switching center 18(1) then confirms (action 230) the proprietary of the assigned channel and hyperband in view of mobile station 16(1) communications capabilities, and signals 232 the mobile station 16(1) via the base station 14(1) for the currently serving cell 12(1) with a handover command directing the mobile station to switch to the assigned traffic channel (and time slot therein if appropriate) in the target cell 12(2). The mobile station 16(1) then tunes to and accesses 234 the assigned traffic channel (in the proper time slot). When the base station 14(2) detects the mobile station access (action 236), the mobile switching centers 18(1) and 18(2) are informed 238, and the call is switched 240 to the mobile switching center 18(2) for further handling to complete the hand-off procedure.

The operation of the network 10 in connection with the blind-type hand-off procedure illustrated in FIGURES 3A-3B may be better understood by reference again to the examples discussed above with respect to FIGURES 2A-2B. The primary difference with respect to FIGURES 2A-2B and its examples comprises the point in time at which the mobile switching center 18(1) requests that base station 14(2) for the target cell 12(2) perform verifying signal strength measurement within the designated hyperband on the designated traffic channel currently being used by the mobile station 16(1). In FIGURES 3A-3B with respect to each of those four examples, the verification signal strength measurement is not made until after the request for assignment of a traffic channel in the target cell 12(2) has been made. Otherwise, the hand-off process and results remain the same.

Although preferred embodiments of the method and apparatus of the present invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements,

modifications and substitutions without departing from the spirit of the invention as set forth and defined by the following claims.

WHAT IS CLAIMED IS:

1. A cellular telephone network, comprising:

a first system area having a plurality of cells including a first cell, the first system area supporting cellular communications on traffic channels in both a first and a second hyperband;

a second system area having a plurality of cells including a second cell, the second system area supporting cellular communications on traffic channels in the first hyperband but not the second hyperband;

a mobile station moving through the network from the first cell into the second cell and engaged in a cellular communication on a traffic channel of either the first or second hyperbands; and

means for signaling from the first system area to the second system area of a request for the second system area to perform a verification signal strength measurement on the traffic channel being used by the mobile station, the request including an identification of the traffic channel being used as well as an identification of the first or second hyperband within which that traffic channel exists.

2. The network as in claim 1 wherein the first system area includes means for identifying the second cell as a target cell for hand-off of the mobile station.

3. The network as in claim 2 wherein the second system area performs the requested verification signal strength measurement from the target second cell.

4. The network as in claim 1 further including means for signaling from the second system area to the first system area of a report on the results of the requested verification signal strength measurement and hyperband capabilities of the target cell.

5. The network as in claim 4 wherein the first system area further includes means for processing the report on the results of the requested verification signal strength measurement to determine whether the second system area can support mobile

station communications with respect to hyperband in the event of a hand-off from the first cell to the second cell.

6. In a cellular telephone network including:

a first system area having a plurality of cells including a first cell, the first system area supporting cellular communications on traffic channels in both a first and a second hyperband; and

a second system area having a plurality of cells including a second cell, the second system area supporting cellular communications on traffic channels in the first hyperband but not the second hyperband;

a method for performing verification signal strength measurements in connection with a potential hand-off from the first cell to the second cell of a mobile station engaged in a cellular communication on a traffic channel of either the first or second hyperbands, comprising the steps of:

signaling from the first system area to the second system area of a request for the second system area to perform a verification signal strength measurement on the traffic channel being used by the mobile station, the request including an identification of the traffic channel being used as well as an identification of the first or second hyperband within which that traffic channel exists; and

considering by the second system area of the identified hyperband in connection with the making and reporting of the verification signal strength measurement.

7. The method as in claim 6 further including the step of identifying the second cell as a target cell for hand-off of the mobile station.

8. The method as in claim 7 further including the step of performing the requested verification signal strength measurement from the target second cell.

9. The method as in claim 6 further including the step of signaling from the second system area to the first system area of a report on the results of the requested verification signal strength measurement and hyperband capabilities of target cell.

10. The method as in claim 9 further including the step of processing the report on the results of the requested verification signal strength measurement to determine whether the second system area can support mobile station communications with respect to hyperband in the event of a hand-off from the first cell to the second cell.

11. A method for operating a cellular telephone network, comprising the steps of:

detecting with respect to mobile station communication operation in a first cell a need to perform a hand-off, the mobile station having certain hyperband communications capabilities;

identifying a target second cell associated with a second system as a candidate cell for hand-off;

requesting that the second cell perform a verification signal strength measurement, the request identifying a traffic channel currently being used by a mobile station in the first cell as well as identification of the hyperband within which that channel exists;

attempting to perform the verification signal strength measurement in the identified traffic channel and hyperband;

reporting results of the attempted verification signal strength measurement and hyperband capabilities of target cell; and

processing the report on the results of the requested verification signal strength measurement to determine whether the second cell would support mobile station communications with respect to its certain hyperband communications capabilities in the event of a hand-off from the first cell to the second cell.

12. The method as in claim 11 wherein the first cell supports mobile station communications in both a first hyperband and a second hyperband.

13. The method as in claim 12 wherein the second cell supports mobile station communications in the first hyperband but not the second hyperband.

14. The method as in claim 13 wherein the step of processing further includes the steps of:

determining from the results of the requested verification signal strength measurement that the second cell supports mobile station communications in the first hyperband but not the second hyperband; and

determining whether the mobile station is capable of operation in the first hyperband.

15. The method as in claim 14 further including the steps of:

requesting a traffic channel in the first hyperband for mobile station hand-off to the second cell; and

transmitting a handover command to the mobile station specifying operation in that traffic channel of the first hyperband.

FIG.1

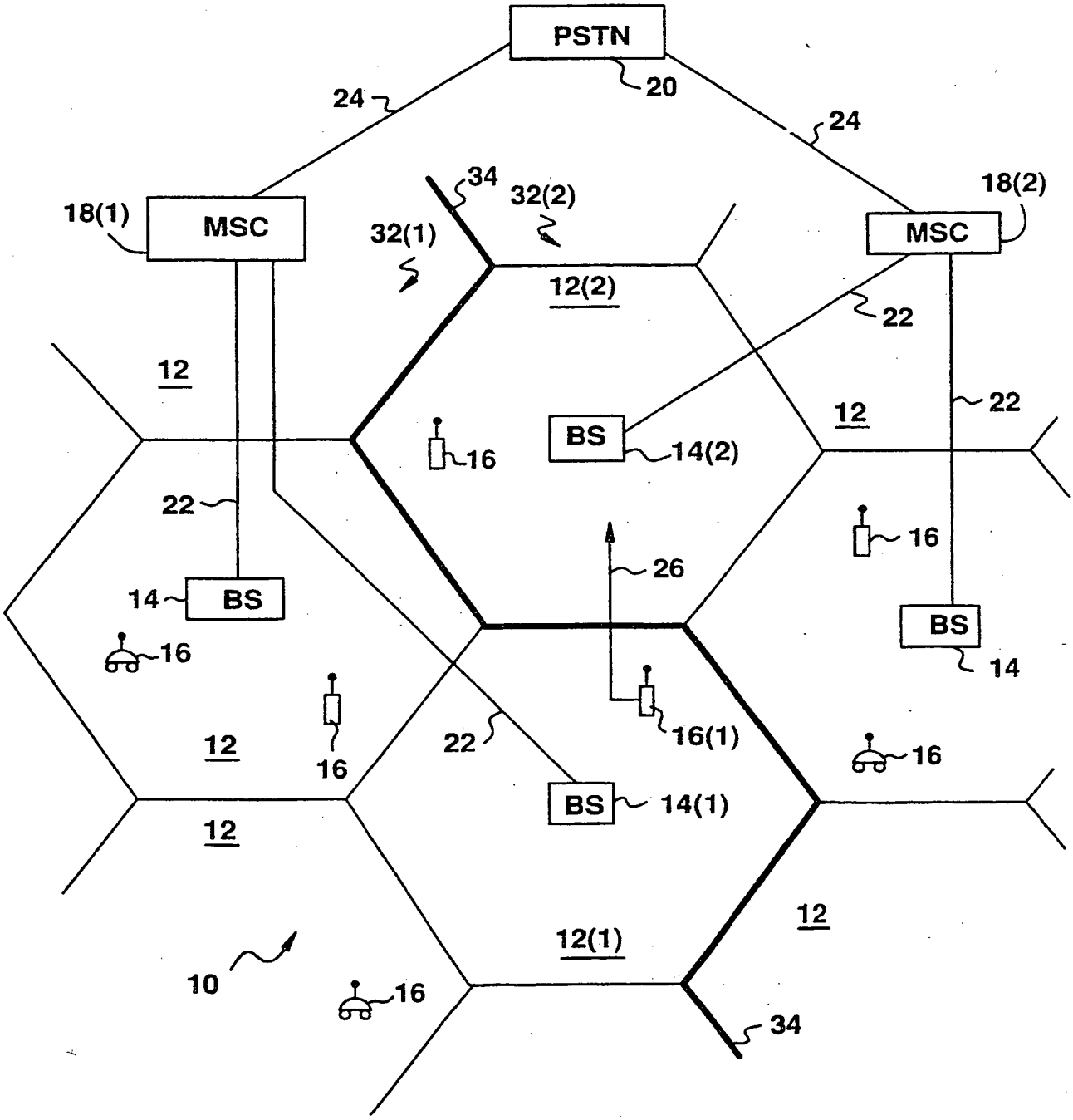

PSTN
20
24
24
18(1)
MSC
18(2)
MSC
34
32(2)
32(1)
12(2)
22
12
12
22
16
BS
14(2)
22
16
26
14
BS
BS
14
16
16(1)
12
16
22
16
BS
14(1)
12
12
12(1)
10
16
34

FIG.2A

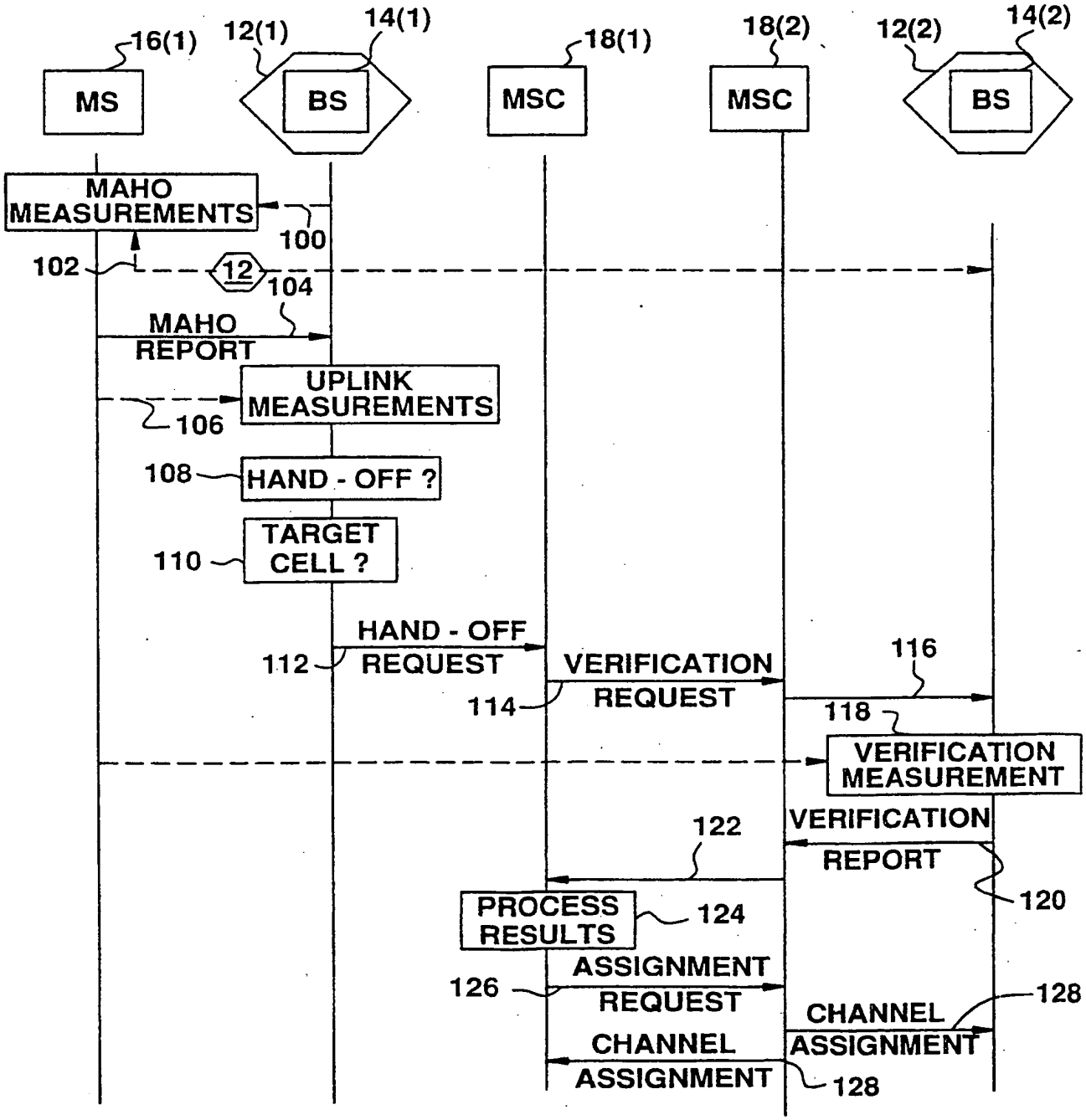

16(1)
MS
12(1)
14(1)
BS
18(1)
MSC
18(2)
MSC
12(2)
14(2)
BS
MAHO MEASUREMENTS
100
102
12
104
MAHO REPORT
UPLINK MEASUREMENTS
106
108
HAND - OFF ?
110
TARGET CELL ?
HAND - OFF REQUEST
112
VERIFICATION REQUEST
114
116
118
VERIFICATION MEASUREMENT
VERIFICATION REPORT
120
122
PROCESS RESULTS
124
ASSIGNMENT REQUEST
126
CHANNEL ASSIGNMENT
128
CHANNEL ASSIGNMENT
128

FIG.2B

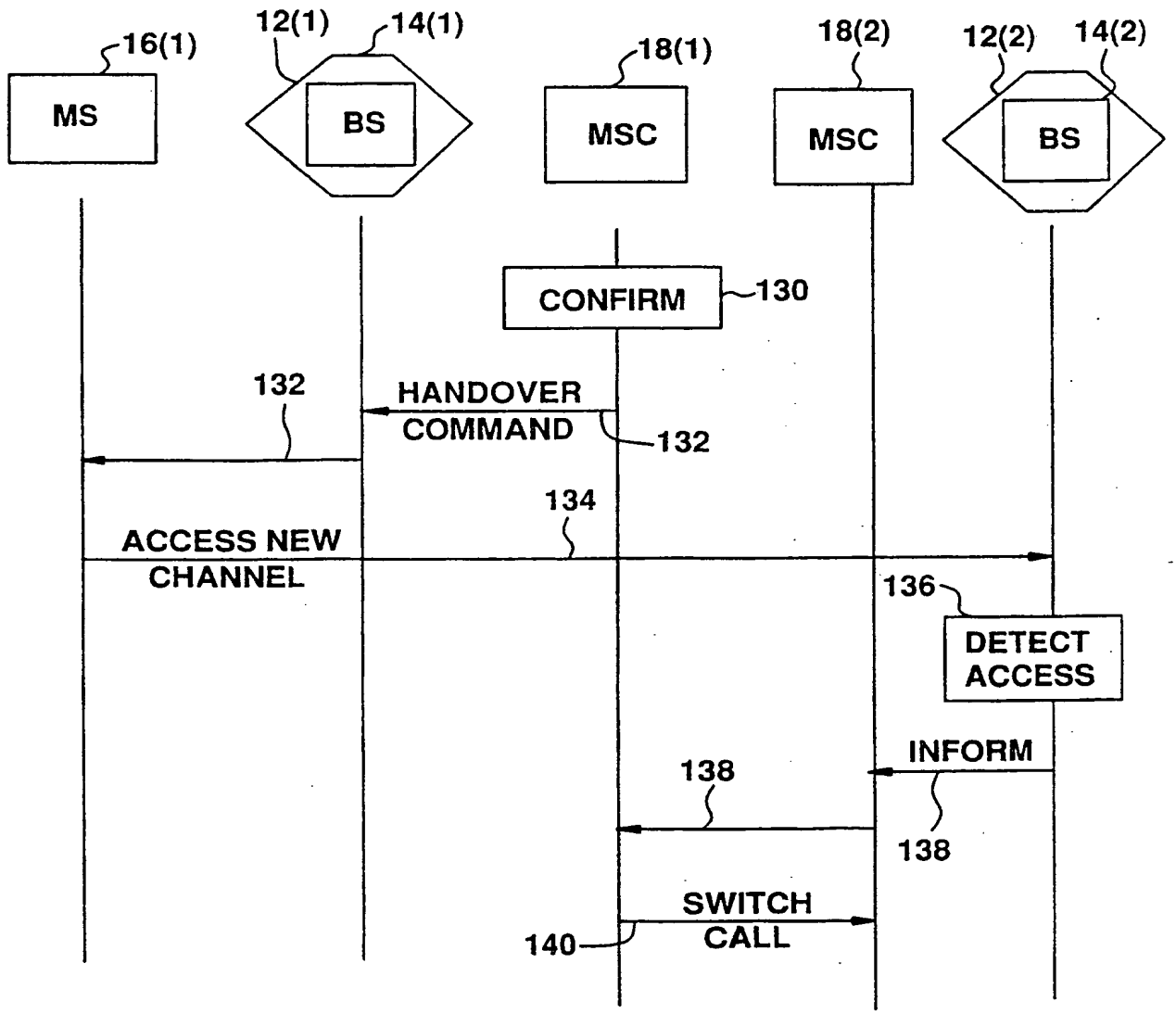

16(1)
MS
12(1)
14(1)
BS
18(1)
MSC
18(2)
MSC
12(2)
14(2)
BS
CONFIRM
130
132
HANDOVER
COMMAND
132
134
ACCESS NEW
CHANNEL
136
DETECT
ACCESS
INFORM
138
138
SWITCH
CALL
140

FIG.3A

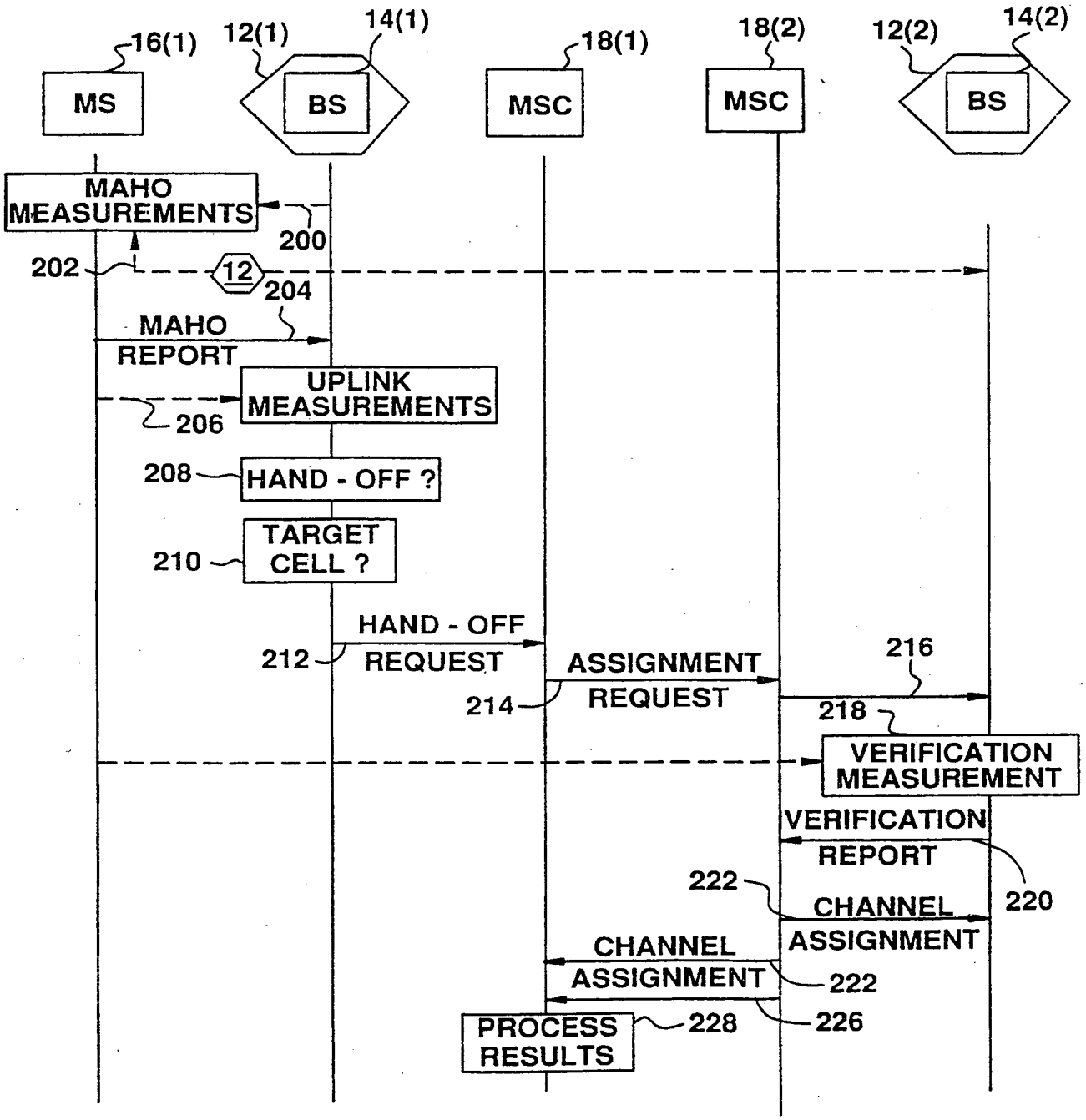
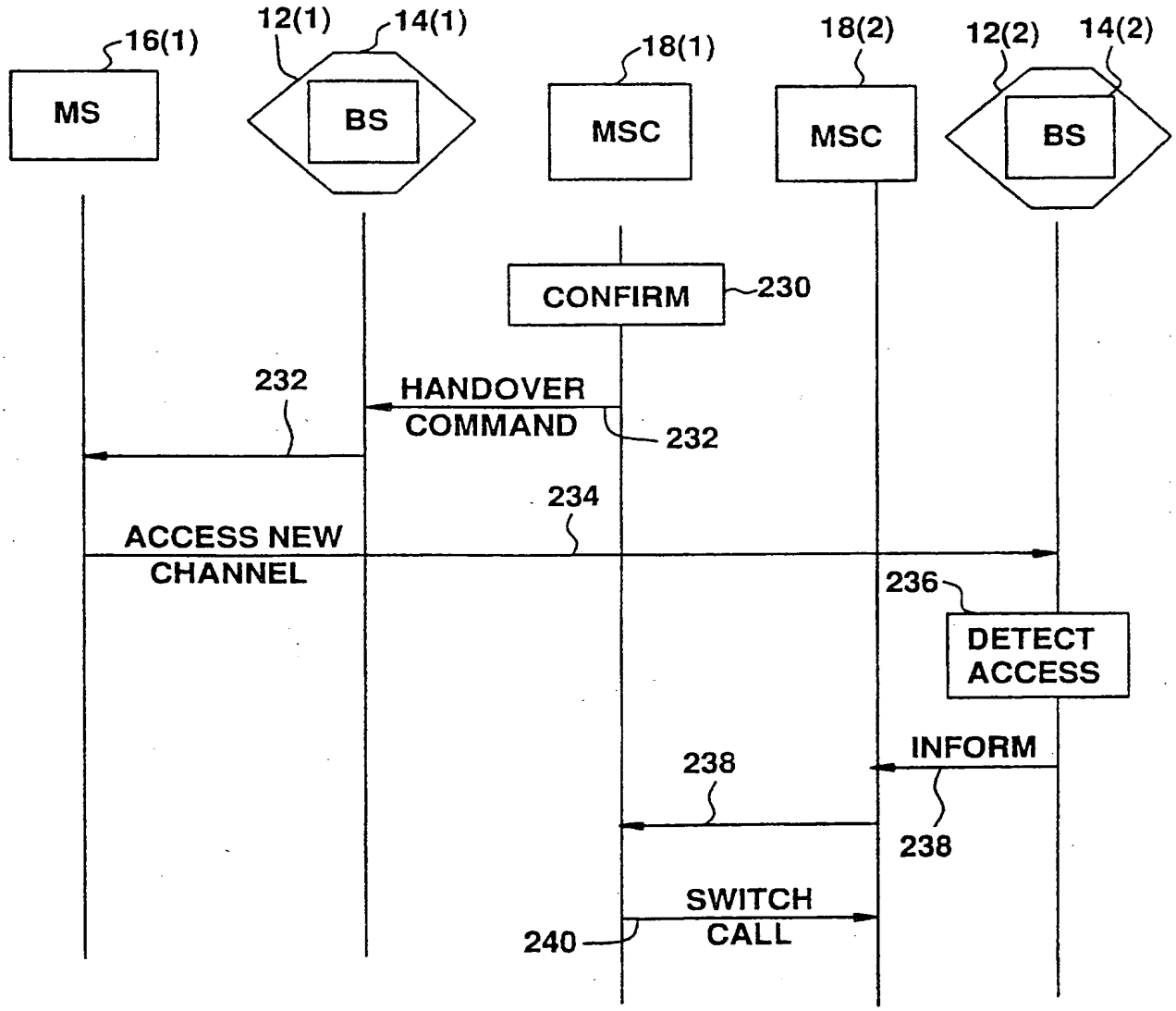

16(1)
12(1)
14(1)
18(1)
18(2)
12(2)
14(2)
MS
BS
MSC
MSC
BS
MAHO MEASUREMENTS
200
202
12
204
MAHO REPORT
UPLINK MEASUREMENTS
206
208
HAND - OFF ?
210
TARGET CELL ?
HAND - OFF REQUEST
212
ASSIGNMENT REQUEST
214
216
218
VERIFICATION MEASUREMENT
VERIFICATION REPORT
220
222
CHANNEL ASSIGNMENT
CHANNEL ASSIGNMENT
222
PROCESS RESULTS
228
226

FIG.3B


16(1)
MS
12(1)
14(1)
BS
18(1)
MSC
18(2)
MSC
12(2)
14(2)
BS
CONFIRM
230
232
HANDOVER COMMAND
232
234
ACCESS NEW CHANNEL
236
DETECT ACCESS
INFORM
238
238
SWITCH CALL
240